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Digging Wide and Narrow: An Exploratory Study of Senior and Younger Users' Strategies for Retrieving Information from a Healthcare Portal

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Abstract. It has been argued that home healthcare systems could provide a solution to the increasing costs posed on healthcare budgets while aiming at a better quality of life for the chronically ill. If telemedicine systems are to succeed in securing these aims they must possess a high level of usability. This paper extends previous usability research in the home healthcare domain by uncovering the strategies applied by a group of seniors and a group of younger participants to retrieve information in relation to the Information Architecture (IA). We found that the group of seniors made significantly more menu selections at deeper rooted menu levels compared to the younger participants and that the seniors made more selection errors. The group of seniors applied an information retrieval strategy that can be illustrated as "digging wide" while the younger team members were "digging narrow" in the IA.

Keywords: Home Healthcare, Information Architecture, Usability evaluation, Seniors.

1 Background

It has been widely argued that home telemedicine systems could provide a solution to the increasing costs posed on healthcare budgets while aiming at a better quality of life for the chronically ill [1], [3], [5], [8], [9], [16]. This cost increase is partially caused by a continuously growing population of seniors within developed countries [1], [5], [8]. For telemedicine systems to succeed in securing decreased costs and patient autonomy they must be intuitive to the end users, i.e. they need a high level of usability [1]. This perspective validates the attention paid to elderly usage of home telemedicine systems and the challenges seniors experience, which is seen within health informatics research.

1.1 Related Work

For the past decade several studies have treated usability engineering within the domain of home healthcare systems. These studies may be distributed according to different research foci such as literature reviews, development of taxonomies, process evaluation, elderly ICT usage and usability problems experienced by that user group. In this section we present five empirically based papers emphasizing usability aspects of systems designed for older adults. In [2] a usability evaluation of a home healthcare device is conducted with 5 elderly users where the focus is on deriving the types of problems experienced. In general, several types of problems were observed which regarded feedback mechanisms, users' mental model, affordance etc. However, one of the main findings from that study shows that most problems are related to the clarity of information provided by the system (Bruun & Stage 2010).

The research presented in [3] is an empirical study based on two usability evaluations of a robotic wheelchair arm. A total of 14 disabled wheelchair users participated in these evaluations. Findings from the study show that the users experienced problems using the patch board interface in general and that chair mobility was decreased due to the extended width posed by the robotic arm. Additionally a survey was conducted with experienced wheelchair users in order to assess user needs [3].

Hubert presents a study focusing on uncovering the usability problems experienced with a home healthcare device [7]. Twenty-one older adults participated in a survey showing that users experienced problems interacting with the physical buttons on the device caused by the small size, lack of texture, location etc. These buttons were examined in more detail in two follow-up studies based on the conduction of usability evaluations. The paper concludes with a set of recommendations for designing device buttons [7].

In [8] a home healthcare system for elderly diabetes patients was evaluated through usability testing. The study provides an overview of various barriers such as individual competencies, system usability issues and contextual variables. Two user examples of these barriers are provided [8].

A study conducted by Kurniawan and Zaphiris focus on the design of a web health information architecture for older users [11]. Researchers applied the card sorting technique together with 49 seniors. Categories for the card sorting were derived from menu items of an existing website and were printed on index cards, which the seniors were asked to sort into logical groups. Findings show that the obtained information architecture differed from that of the existing website. The architecture on the existing website had four branches with two sub-categories and each sub-category contained two items. The architecture derived by the seniors was less structured with varying numbers of items and sub-categories in each branch. Additionally, seniors grouped items together based on their function or service provided, instead of factors such as geographic location [11].

2 Objectives

The above mentioned empirical research mainly provides holistic views of the usability engineering process and of the problems experienced within user interfaces. In terms of user interfaces these holistically oriented studies cover several design elements such as feedback mechanisms, help functions, system visibility, consistency etc., see e.g. [2], [3], [8]. Although such holistic views are useful we find that there is a need to further narrow the focus on specific design elements within user interfaces of telemedicine systems and to conduct in depth studies of these. As an example the study conducted by Hubert specifically focus on usability problems related to the design of physical buttons [7]. Another example is the study presented in [11] where the focus is on designing a new information architecture (IA). One of the main findings in [2] is that elderly users experienced problems in understanding the information given, which indicates that the IA of such systems provides a relevant focal point for future research. The IA is a crucial element to consider as it determines the way in which information is categorized, labeled and presented, and, thus, whether users are able to locate relevant information efficiently [4].

The objective of this paper is to uncover the strategies applied by different user groups to retrieve information as well as uncovering the reasons why these strategies are applied in relation to the IA. The SmartSenior healthcare portal is used as a case [17]. Performance of a group of senior users is compared to a group of younger users.

3 Research Method

3.1 System

The SmartSenior healthcare portal offers various features such as communication with the hospital and other seniors, advice for healthy diets and room climate, measurements of vital parameters etc. The system is aimed for use by seniors in their homes and all user interaction is done through a web portal aimed for display on a TV using a remote control. External devices are required to conduct measurements of blood pressure, weight etc. In this experiment we evaluated a subset of these features, see Table 1 for the list of tasks.

3.2 Setting

The usability evaluations were conducted in a room at the telemedicine center, see Fig. 1. In the test room, a test participant was sitting in a chair operating the portal using a remote control. A test monitor was sitting next to the participant and a data logger was standing in the test room behind the test participant and test monitor to observe all test sessions and take notes.

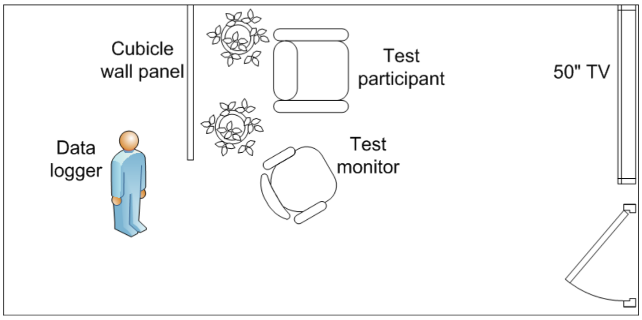

Fig. 1. Overview of settings.

3.3 Participants

The system primarily is intended for use by elderly people, therefore we selected 6 test subjects in one group ranging from 62 to 74 years of age. We were also interested in comparing their performance to how the portal would be operated in optimal conditions. For this reason we chose to include a control group consisting of 6 younger users. Common for this control group was, that they all were employed at the Tele Medicine Center Charité (TMCC) and, for this reason, had a higher level of domain knowledge compared to the group of senior users. All 12 participants were female where the group of seniors had a mean age of 67.2 years (SD=3.9) and the mean age of the team members had a mean age of 35,3 years (SD=5.6). Although 6 participants in each group is relatively small number, it should be noted that formative usability evaluations in the domain of Human Computer Interaction are typically conducted using 5 test participants. From a cost/benefit point of view, this is the most feasible. This number is based on the study presented in [14], which shows that 5 test participants enables evaluators to identify 85 % of the total number of usability problems. None of the participants had previous experience with this or any similar portal system. Their experience in using electronic equipment in general varied. All users owned a cell phone; five of six team members owned a smartphone and only one of six seniors owned a smartphone which was just recently bought.

Three usability evaluators were involved in the experiment (the first three authors of this paper). Two of them served as test monitors in the test sessions and the third acted as data logger. One of these is a Human-Computer Interaction specialist, one an IT-scientist and one a medical doctor with experience in usability evaluation.

3.4 Procedure

Before the evaluations started, the test participants were asked to fill in a questionnaire with demographic information. The test monitor then introduced the system and evaluation procedure. This included an introduction to the think-aloud protocol as all participants were asked to think aloud and state their intentions and expectations while solving a series of tasks. The tasks were then given to the test subjects one at a time. The test monitor's job was primarily to ensure that the test participants were thinking aloud and give them advice if they got completely stuck in a task. Participants were asked to solve the 6 tasks shown in Table 1.

Table 1. Overview of task descriptions.

Task #	Task description
1	Log into the healthcare portal.
2	Find the menu where you can change font size.
3	Find the menu from where you can get your heating fixed.
4	Find the log of your vital data.
5	Find the menu where you can create an audio/video connection to the telemedicine center.
6	Find the menu where you can log out of the system.

3.5 Data collection

All test sessions were recorded using screen capture software, a webcam and a microphone. The videos showed the SmartSenior user interface and a small picture in picture with the user's face and their interaction with the remote control, see Fig. 2. We recorded a total of 4:15 (hh:mm) of video. The data logger made written log files of participants' menu selections in the IA during the evaluation sessions.

Fig. 2. Screenshot of video recordings. Left: Main menu (level 1). Right: Sub menu (level 2).

3.6 Data Analysis

We conducted a conventional video based analysis in accordance with [15] to identify the usability problems experienced by the test participants. The three evaluators analyzed the video material individually and made a list of identified usability problems. The severity of each problem was also categorized as either "critical", "serious" or "cosmetic" [12]. The three lists of usability problems were discussed by the three evaluators and then merged into one list of usability problems. When there was disagreement or doubt whether problems should be combined or split, or how they should be categorized, the video material was reviewed and discussed until agreement was reached. This included agreement about the test subjects who experienced each problem. To measure the inter rater reliability of this qualitative analysis we calculated the any-two agreement, cf. [6]. This denotes the extent to which all pairs of evaluators agree on observed usability problems. The any-two agreement was 43.7% in our case, which is above the minimum of 6% and close to the 42% maximum found in other studies [6].

Additionally, the written logs made by the data logger during the evaluation sessions represented how the participants interacted with the menus in the form of the paths taken. Fig. 3 provides an example of a path in the IA where a participant made one selection at levels 1 and 2 after which she made multiple selections in the third and fourth menu levels. These notes were analyzed quantitatively by the data logger in terms of the number of menu selections made at different levels in the IA.

Finally, one of the evaluators reviewed all videos to extract quantitative data on the time participants spent completing each of the 6 tasks.

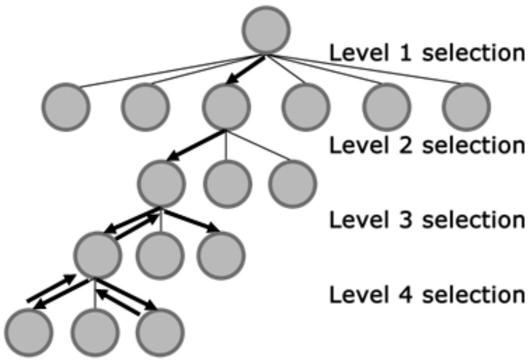

Fig. 3. Example of a path taken by one of the participants at different menu levels in the IA.

4 Results

This section presents the results by firstly providing quantitative findings on how the two participant groups interacted with the menus followed by qualitative data describing the usability problems related to the IA.

4.1 Menu Selections

Table 2 provides an overview of the mean number of menu selections made by the participant groups at the four menu levels in the IA (S=Seniors, TM=Team members). Note that task 1 is not included as the log in screen was part of the front page and, hence, no menus were selected to complete this task. Looking at the overall means, we found that the group of seniors consistently made more menu selections than the team members and that this pertains to all four menu levels in the IA. At level 1 the seniors on average make 2.43 (SD=3.45) menu selections while the team members make 1.73 (SD=0.98) selections. At level 2 this number is 2.99 (SD=2.99) for the group of seniors and 1.33 (SD=1.18) for the team members. The mean number of menu selections at level 3 is 2.39 (SD=3.37) in case of the seniors and 1 (SD=0) for team members while the overall mean for the seniors at level 4 is 1.55 (SD=1.75) and 1 (SD=0) for the team members. Welch's two sample t-test (unequal variances) reveals no significant differences between the number of menu selections made by seniors and team members at level 1 in the IA (t=1.18, df=32.35, p=0.25). There are, however, significant differences between these groups at levels 2 ($t=2.92$, $df=36.34$, $p=0.006$), 3 ($t=3.68$, $df=18$, $p=0.0017$) and 4 ($t=3.25$, $df=9$, $p=0.001$). Thus, the group of seniors make significantly more menu selections at these levels than the group of team members. Figure 4 presents a visualization of Table III where the line thickness corresponds to the mean number of selections, e.g. the level 1 line for the seniors is 243 pixels wide corresponding to the mean of 2.43 etc.

Table 2. Mean number of menu selections made by the participants groups at the four menu levels in the IA (S=Seniors, TM=Team members). Exclamation marks (!) denote menu selections made by one group but not the other at a particular menu level.

	Level 1		**Level 2**		**Level 3**		**Level 4**	
	S	*TM*	*S*	*TM*	*S*	*TM*	*S*	*TM*
Task 2	1.67	1	2.33	1	0.67**!**			
Task 3	2.67	2	4.83	1	4.33	1	1.5	1
Task 4	1.33	1	5.33	1.33	5	1	2.33**!**	
Task 5	1.5	2	1.5	2.33	2.17	1	0.83**!**	
Task 6	5	2.67	1	1				
Overall mean	**2.43**	**1.73**	**2.99**	**1.33**	**2.39**	**1**	**1.55**	**1**

Table 2 also shows that the groups of seniors make more selections at level 2 than at level 1 and that the team members make more selections at level 1 than any of the underlying menus. The exclamation marks (!) at levels 3 and 4 denote that menu selections were made at these levels by the group of seniors but not by the team members. Thus, in tasks 2, 4 and 5 the seniors selected deeper rooted menus than the team members and they made between 0.67 and 2.33 selections in these cases. Thus, the strategy applied by the group of seniors tends to be to select a menu at level 1 in the IA after which they make most selections in the underlying menus, i.e. they are digging "wide" for relevant information in lower menu levels. Team members use another strategy where they tend to make most selections at level 1 and tend to move up one level and try a different menu if they do not find the correct information, i.e. they are digging more "narrow" in the underlying menus compared to the seniors. This is also illustrated in Fig. 4 where the lines for the group of seniors are wider than those of the team members.

Table 3 and Table 4 show an overview of the total number of correct and wrong menu selections at levels 1 and 2 made by the two groups of participants. We haven chosen to focus on these two levels as this is where the seniors made most selections. At level 1 (the main menu) the seniors made 40 correct and 14 incorrect selections. This gives a total of 54 selections with a 26 % error rate, i.e. 14 of 54 selections were incorrect. In comparison the team members made 31 correct and 9 incorrect selections with a 23 % error rate. Looking at level 2 the seniors made 29 correct and 23 incorrect selections which reveals an error rate of 44 %. In this case the team members made 31 correct and 2 incorrect and an error rate of 6 %. Thus, considering level 1 selections the seniors had an error rate similar to that of the team members while the seniors made considerably more errors at level 2 compared to the team members.

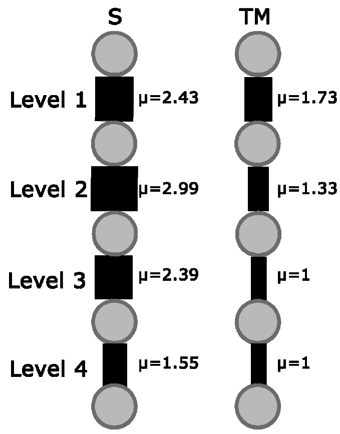

Fig. 4. Visualization of mean number of menu selections for the two participant groups at diferent menu levels (S = Seniors, TM = Team members). Line thickness corresponds to the mean number of selections at particular menu levels.

Table 3. Total number of correct (+) and incorrect (-) level 1 menu selections made by the two groups of participants (S = Seniors, TM = Team members).

	Level 1 selections											
	Task 2		**Task 3**		**Task 4**		**Task 5**		**Task 6**		**Total**	
	+	-	+	-	+	-	+	-	+	-	**+**	**-**
S	6	1	10	2	10	0	8	0	6	11	**40**	**14**
TM	6	0	6	2	6	0	7	1	6	6	**31**	**9**

Table 4. Total number of correct (+) and incorrect (-) level 2 menu selections made by the two groups of participants (S = Seniors, TM = Team members).

	Level 2 selections											
	Task 2		**Task 3**		**Task 4**		**Task 5**		**Task 6**		Total	
	+	-	+	-	+	-	+	-	+	-	+	-
S	6	1	4	9	6	12	7	1	6	0	29	23
TM	6	0	6	0	6	1	7	1	6	0	31	2

4.2 Usability Problems

In the above we found that the seniors made significantly more menu selections at levels 2, 3 and 4 than the group of team members and that the seniors had a considerably higher error rate when making level 2 selections. In this section we describe the usability problems experienced by the group of seniors, which provides qualitative insights into why these participants made more menu selections as well as more incorrect selections than the team members. We found that a considerable amount of usability problems experienced by the seniors could be characterized according to the categories of information, visibility and users' mental model, cf. [2], [13].

The information category covers problems in understanding the information, e.g. wording, given to the users in the interface. In task 3 the participants for instance were asked to find out how to get the heating fixed. In this case most of the seniors initially located the level 1 menu labeled "At Home" correctly, but they experienced problems in the underlying menus at level 2. One of the usability problems is that seniors expected to be able to contact the janitor through the menu labeled "Information and Advice", but this did not provide the correct information after which they returned to the "At Home" menu. Another information related problem is that seniors wrongfully believed the menu labeled "Devices and Room Sensors" to be the correct one. In this case they browsed through the selected menu, but it did not provide the correct information after which they returned to the "At Home" menu. A third example of an information related problem is that the seniors selected the menu "Consumption Values" after browsing through the "At Home" menu. Again they went through this submenu without any luck and once more returned to the previous menu. All the above mentioned problems were only experienced by the group of seniors.

Another type of usability problem observed is that of visibility, which regards how well the interface presents available interactive resources. As an example of such a problem the healthcare portal did not offer any visual cues about how to go back to upper menu levels. For this reason we observed that the seniors found it difficult to go back to higher menu levels once deeper rooted menus were selected. We observed that the seniors were stuck within the second or third menu levels where thay made several selections, and in some cases it was unclear for them that they were able to move back to the main menu to get an overview. This caused them to spend a considerable amount of time at these deeper levels.

The third type of usability problem observed was related to missing correlation between the users' mental model and the model supported in the system. As an example all seniors experienced difficulties in completing task 4 where they were asked to locate a log of their vital data. At level 1 all selected the correct menu labeled "Health", but none of them found the correct menu at level 2 the first time, which is called "Personal Health Record". Instead all seniors selected the menu labeled "Contact the Telemedicine Center" from where they attempted to make several audio/video connections without finding the needed information. This problem was rated as critical as most of the seniors needed help by the test monitor to complete this task. Thus, this problem is related to deviations in the seniors' mental model as they expected that vital data should be obtained by contacting the telemedicine center rather than having direct access to these through the healthcare portal.

5 Discussion

The study by Kurniawan and Zaphiris focus on the design of a web health information architecture for older users [11]. In that study the card sorting technique was applied where initial card categories were derived from menu items of an existing website. Seniors were asked to sort these cards into logical groups and findings show that the information architecture suggested by the seniors differed from that of the existing website. Our findings support this in the sense that the initial information architecture does not support the group of seniors to the same extent as it supports the younger group of team members. We found that the seniors made significantly more menu selections at levels 2, 3 and 4 compared to the team members and that the seniors had a considerably higher error rate at level 2. An interesting finding is that the seniors had a considerably lower error rate when interacting with the level 1 menu, i.e. they made fewer errors in this case. An apparent explanation of this difference could have been a variation in the number of menu items, e.g. if the level 1 menu had fewer items than level 2 menus. This, however, is not the case in the evaluated system as the level 1 menu had six menu items while level 2 menus had in the range of five to eight items. A more likely explanation may be the design of the menus which differed considerably. As shown in Fig. 2 the level 1 menu was designed using text and icons with all items visible on the screen at the same time. Deeper rooted menus were text only of which three to four items were displayed at once, see Fig. 2. These menu designs provided participants with an overview of all items at level 1 but not at deeper levels. Thus, since the seniors made significantly more selections than the younger team members at levels 2 and below as well as making considerably more errors at level 2, our findings suggest that seniors tend to be sensitive to lack of overview in the IA than younger persons.

In an effort to explain why these two information retrieval strategies occur we conducted a qualitative analysis of the video material from the evaluation and found that senior participants in particular experienced certain types of usability problems. These problems were related to misunderstandings of the information provided in the menus as well as missing visibility of system options and finally missing correlation between users' mental model and the model adopted in the healthcare portal. Similar findings are presented in [2] where a usability evaluation of a home healthcare device was conducted with 5 senior users. In that study several types of usability problems were observed of which most problems were related to the clarity of information provided by the system. Problems regarding the support of the users' mental model were also found.

Taken together, the lack of overview of items within deeper rooted menu levels and the above mentioned usability problems caused the group of senior participants to apply an information retrieval strategy which can be described as "digging wide" while the younger team members were "digging narrow".

6 Conclusions

The objective of this study was to uncover the strategies applied by seniors and younger users to retrieve information from the SmartSenior healthcare portal. A second purpose was to uncover the reasons why these strategies were applied in relation to the Information Architecture (IA). We found that the group of seniors made significantly more menu selections at levels 2, 3 and 4 in the IA compared to the team members. Additionally we found that, in comparison, the group of seniors and younger participants had similar error rates when making selections at level 1 and that seniors had a considerably higher error rate at level 2. This difference may be explained by the lack of overview of menu items at level 2, which differed from the design applied at level 1 where all menu items were visible. Based on our qualitative analysis we uncovered usability problems which had a negative effect on understanding the IA. These problems were related to information, visibility of system options and correlation between users' mental model and the model of the healthcare portal. This caused the group of seniors to apply an information retrieval strategy that can be illustrated as "digging wide" while the younger team members were "digging narrow".

This study is limited in several ways. Firstly, we only had 6 participants in each group, which limits the generalizability of our findings. Secondly, we only had female participants, which may show a different behavior than male participants.

Acknowledgements

FIXME: Any suggestions of what to mention here?

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